

Name Key

### Acids and Bases Practice Test

1. The hydrogen sulfate or bisulfate ion  $\text{HSO}_4^-$  can act as either an acid or a base in water solution. In which of the following equations does  $\text{HSO}_4^-$  fit the definition of an acid?

- a)  $\text{HSO}_4^- + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4 + \text{OH}^-$
- b)  $\text{HSO}_4^- + \text{H}_3\text{O}^+ \rightarrow \text{SO}_3 + 2\text{H}_2\text{O}$
- c)  $\text{HSO}_4^- + \text{OH}^- \rightarrow \text{H}_2\text{SO}_4 + \text{O}^{2-}$
- ☒ d)  $\text{HSO}_4^- + \text{H}_2\text{O} \rightarrow \text{SO}_4^{2-} + \text{H}_3\text{O}^+$
- e) none of these

2. Which of the following is a conjugate acid/base pair?

- a)  $\text{HCl}/\text{OCl}^-$
- b)  $\text{H}_2\text{SO}_4/\text{SO}_4^{2-}$
- ☒ c)  $\text{NH}_4^+/\text{NH}_3$  *off by 1  $\text{H}^+$*
- d)  $\text{H}_3\text{O}^+/\text{OH}^-$
- e) none of these

3. The dihydrogenphosphate ion,  $\text{H}_2\text{PO}_4^-$ , has both a conjugate acid and a conjugate base. These are, respectively:

- a)  $\text{H}_3\text{PO}_4, \text{PO}_4^{3-}$
- ☒ b)  $\text{H}_3\text{PO}_4, \text{HPO}_4^{2-}$  *conj acid = 1 extra  $\text{H}^+$*
- c)  $\text{H}_2\text{PO}_4^-, \text{HPO}_4^{2-}$  *conj base = 1 less  $\text{H}^+$*
- d)  $\text{HPO}_4^{2-}, \text{PO}_4^{3-}$
- e)  $\text{HPO}_4^{2-}, \text{H}_3\text{PO}_4$

4. Given the following acids and  $K_a$  values:

$\text{HClO}_4$	$\text{HOAc}$	$\text{HCN}$	$\text{HF}$
$1 \times 10^7$	$1.76 \times 10^{-5}$	$4.93 \times 10^{-10}$	$3.53 \times 10^{-4}$

which shows the conjugate bases listed by increasing strength?

- a)  $\text{CN}^-, \text{F}^-, \text{OAc}^-, \text{ClO}_4^-$
- b)  $\text{CN}^-, \text{OAc}^-, \text{F}^-, \text{ClO}_4^-$
- c)  $\text{CN}^-, \text{ClO}_4^-, \text{F}^-, \text{OAc}^-$
- d)  $\text{ClO}_4^-, \text{OAc}^-, \text{CN}^-, \text{F}^-$
- ☒ e)  $\text{ClO}_4^-, \text{F}^-, \text{OAc}^-, \text{CN}^-$

*conj of strong acid*  
*conj of the weakest acid*

5. Which of the following is the equilibrium constant expression for the dissociation of the weak acid HOCl?

a)  $K = \frac{[H^+][OCl^-]}{[HOCl]}$

b)  $K = [H^+][OCl^-]$

c)  $K = \frac{[HOCl]}{[H^+][OCl^-]}$

d)  $K = \frac{[H^+][O^{2-}][Cl^-]}{[HOCl]}$

e) none of these

6. What is the equilibrium constant for the following reaction?



The  $K_a$  value for  $HN_3$  is  $1.9 \times 10^{-5}$ .

a)  $5.3 \times 10^{-10}$

b)  $1.9 \times 10^{-9}$

c)  $1.9 \times 10^{-5}$

d)  $5.3 \times 10^4$

e)  $1.9 \times 10^9$

for reverse reaction

$$K_{rev} = \frac{1}{K_{forward}}$$

7. Calculate the pH of a 0.050 M strong acid solution.

a) -1.30

b) 1.30

c) 12.70

d) 15.30

e) none of these

$$-\log(0.050) = 1.30$$

8. Calculate the  $[H^+]$  in a solution that has a pH of 11.70.

a) 2.3 M

b) 11.7 M

c)  $5.0 \times 10^{-3}$  M

d)  $2.0 \times 10^{-12}$  M

e) none of these

$$10^{-11.70} = 2.0 \times 10^{-12} \text{ M}$$

9. Solid calcium hydroxide is dissolved in water until the pH of the solution is 10.94. The hydroxide ion concentration  $[OH^-]$  of the solution is:

a)  $1.1 \times 10^{-11}$  M

b) 3.06 M

c)  $8.7 \times 10^{-4}$  M

d)  $1.0 \times 10^{-14}$  M

e) none of these

$$pOH = 14 - 10.94 = 3.06$$

$$[OH^-] = 10^{-3.06} = 8.7 \times 10^{-4} \text{ M}$$

10. For weak acid, HX,  $K_a = 1.0 \times 10^{-3}$ . Calculate the pH of a 0.10 M solution of HX.

- a) 2.00
- b) 3.50
- c) 3.00
- d) 2.50

☒ e) none of these

	HX	H <sup>+</sup>	X <sup>-</sup>
I	.10	0	0
C	-X	X	X
E	.1-X	X	X

$$1.0 \times 10^{-3} = \frac{X^2}{.1 - X}$$

$$1 \times 10^{-4} - 1 \times 10^{-3} X - X^2 = 0$$

$$X = .00951$$

$$pH = 2.02$$

11. Acetic acid ( $HC_2H_3O_2$ ) is a weak acid ( $K_a = 1.8 \times 10^{-5}$ ). Calculate the pH of a 17.6 M  $HC_2H_3O_2$  solution.

- a) 4.31
- b) 6.40
- ☒ c) 1.75
- d) 0.97
- e) 7.40

$$1.8 \times 10^{-5} = \frac{X^2}{17.6}$$

$$X = .0178$$

$$-\log(.0178) = 1.75$$

12. How many moles of benzoic acid, a monoprotic acid with  $K_a = 6.4 \times 10^{-5}$ , must be dissolved in 500. mL of  $H_2O$  to produce a solution with pH = 2.50?

- a)  $1.6 \times 10^{-1}$
- b)  $2.0 \times 10^{-2}$
- ☒ c)  $7.8 \times 10^{-2}$
- d) 0.50
- e) none of these

$$[H^+] = 10^{-2.5} = 3.16 \times 10^{-3}$$

$$K_a = 6.4 \times 10^{-5} = \frac{(3.16 \times 10^{-3})^2}{[HA]}$$

$$[HA] = .1563 M$$

$$\frac{X}{.500 L} = .1563 M$$

$$X = 0.078 \text{ mol}$$

13. The pH of a 0.100 M solution of an aqueous weak acid (HA) is 3.20. The  $K_a$  for the weak acid is:

- a)  $6.3 \times 10^{-4}$
- b)  $7.2 \times 10^{-5}$
- ☒ c)  $4.0 \times 10^{-6}$
- d) 3.2
- e) none of these

$$[H^+] = 10^{-3.2} = 6.31 \times 10^{-4} M$$

$$K_a = \frac{(6.31 \times 10^{-4})^2}{(.1 - 6.31 \times 10^{-4})} = 4.0 \times 10^{-6}$$

14. A solution of 8.0 M formic acid ( $\text{HCOOH}$ ) is 0.47% ionized. What is the  $K_a$  of formic acid?

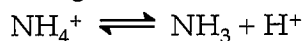
- a)  $3.4 \times 10^{-8}$   
 b)  $1.8 \times 10^{-4}$   
 c)  $6.9 \times 10^{-6}$   
 d)  $3.8 \times 10^{-2}$   
 e) need more data

	$\text{HCOOH}$	$\text{H}^+$	$\text{COOH}^-$
I	8.0	0	0
C	-0.0376	+x	+x
E	7.9624	.0376	.0376

$$K_a = \frac{(.0376)^2}{7.9624} = 1.8 \times 10^{-4}$$

15. As water is heated, its pH decreases. This means that
- a) the water is no longer neutral.  
 b) the  $K_w$  value is decreasing.  
 c) the water has a lower  $[\text{OH}^-]$  than cooler water.  
 d) the dissociation of water is an endothermic process.  
 e) none of these.

16. If you know  $K_b$  for ammonia,  $\text{NH}_3$ , you can calculate the equilibrium constant,  $K_a$ , for the following reaction:



by the equation:

- a)  $K_a = K_w K_b$   
 c)  $K_a = 1/K_b$

- b)  $K_a = K_w / K_b$   
 d)  $K_a = K_b / K_w$

17. Calculate the pH of a 0.02 M solution of KOH.

- a) 1.7  
 b) 2.0  
 c) 12.0  
 d) 12.3  
 e) none of these

$$\text{pOH} = -\log(.02) = 1.7$$

$$14 - 1.7 = 12.3$$

18. Calculate the pH of a 0.10 M solution of pyridine ( $\text{C}_5\text{H}_5\text{N}$ ;  $K_b = 1.7 \times 10^{-9}$ ):

- a) 8.15  
 b) 5.88  
 c) 9.12  
 d) 11.24  
 e) none of these

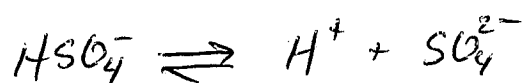
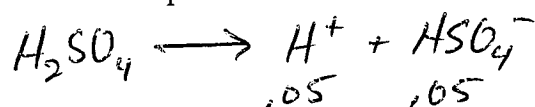
$$1.7 \times 10^{-9} = \frac{x^2}{.10}$$

$$x = [\text{OH}^-] = 1.3 \times 10^{-5}$$

$$\text{pOH} = 4.88$$

$$14 - 4.88 = 9.12$$

19. Calculate the pH of a 0.050 M solution of  $\text{H}_2\text{SO}_4$  ( $K_{a1}$  = very large;  $K_{a2} = 1.2 \times 10^{-2}$ ).



$$[\text{H}^+] = .050 + .019 = .069$$

$$.012 = \frac{x^2}{(.05 - x)}$$

$$\text{pH} = -\log(.069)$$

$$\text{pH} = 1.16$$

$$.0006 - .012x - x^2 = 0$$

$$x = .019$$

20. The pH of a 1.0 M sodium acetate solution is:

- a) 7.0
- ☒ b) greater than 7.0
- c) less than 7.0
- d) not enough information is given
- e) none of these (a-d)

→ conjugate of a weak acid

21. What is the pH of a 0.45 M KCl solution?

- a) 10.50
- ☒ b) 7.00
- c) 9.20
- d) 1.40
- e) 4.50

→ neutral

KOH & HCl are both strong

22. Calculate the pH of a 0.30 M solution of  $\text{NH}_4\text{Cl}$ . ( $K_b$  for  $\text{NH}_3 = 1.8 \times 10^{-5}$ )

- a) 3.33
- ☒ b) 4.89
- c) 9.11
- d) 7.00
- e) 11.67



$$K_a = \frac{10^{-14}}{1.8 \times 10^{-5}}$$

$$K_a = 5.56 \times 10^{-10}$$

$$5.56 \times 10^{-10} = \frac{x^2}{.30}$$

$$x = 1.3 \times 10^{-5}$$

$$\text{pH} = -\log(1.3 \times 10^{-5}) = 4.89$$